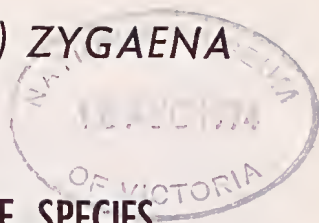


A TASMANIAN RECORD OF *SPHYRNA* (*SPHYRNA*) *ZYGAENA*
(LINNÉ, 1758)

(SPHYRNIDAE), WITH A CONSIDERATION OF THE SPECIES
OF HAMMERHEAD SHARKS IN AUSTRALIAN WATERS



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(one text figure)

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ABSTRACT

A Tasmanian example of *Sphyrna* (*Sphyrna*) *zygaena* (Linné, 1758), from George Bay, Cornwall/Dorset, is described and figured. A second hammerhead shark from the same locality is provisionally determined, on the evidence of a photograph, as the same species. Though this species appears in early papers in this country, it has disappeared from Australian systematics over the last forty years. Some consideration is given to the status in the Australian sphyrnid fauna of this species, and, briefly, of some other species. The Australian list, given in the latest catalogues, Munro (1956), Whitley (1964) as *S. (S.) levini* (Griffith & Smith, 1834) and *S. (S.) ligo* Fraser-Brunner, 1950, is found to comprise *S. (S.) zygaena* (Linné, 1758), *S. (S.) levini* (Griffith & Smith, 1834), *S. mokarran* (Ruppell, 1835), and, with some doubt, *S. (E.) blochii* (Cuvier, 1816), a key to which is provided.

Material. - The specimen described and figured is a young male example of *Sphyrna* (*Sphyrna*) *zygaena* (Linné, 1758), 610 mm in total length, collected by Mr E. Gatenby in George Bay, Cornwall/Dorset, Tasmania on 17 April 1970; Q.V.M. reg. no. 1970.5.14.

In the Launceston Examiner of 16 February 1971 there appeared a photograph of a large sphyrnid with the caption "The first hammerhead shark ever caught in Tasmanian waters under game fishing rules was baited at the weekend by St Helens charterboat skipper, Mr Tom Tucker. The shark weighed 206 lb and measured 9 ft in length, with a girth of 5 feet." As far as can be judged from a copy of the original black and white photograph, which provides a tolerably clear view of the head, this shark was very probably an example of *S. (S.) zygaena*. St Helens is on George Bay, the locality of the Museum's shark.

No other specimen of a hammerhead is at present available in this Museum's collections, and Mr A. P. Andrews, Curator of Vertebrates, Tasmanian Museum, Hobart, informs me no examples are possessed by his institution.

Methods.- Except where otherwise noted (*e.g.*, marked "direct"), or where clearly inapplicable, all dimensions are measured between parallels. This is in agreement with fairly general practice, and conforms to specifications for biometric data for sharks formulated by Whitley (1943:114). Methods of procedure used in the taking of measurements are essentially those adopted by Springer (1964:562-568) and followed by Gilbert (1967).

Family status; subgenera.- The sphyrnids share many important morphological characters with the carcharinids, and the hammerheads are referred to the Carcharinidae by some writers, *e.g.*, Regan (1906), Norman [unpublished MS classification - *vide* Gilbert (1967)]. However they are accorded family rank as the Sphyrnidae in most major works on classification, *e.g.*, Gill (1861), Jordan (1923), White (1937), Berg (1940), a procedure followed here. [By some early local writers, working with older concepts of elasmobranch families, they are referred to the Carcharidae or Carchariidae (modern Odontaspidae); being so treated by, *e.g.*, Castlenau (1872), Macleay (1882), Johnston (1883, 1891)].

It is debatable, and debated, whether *Platysqualus* Swainson, 1839 and *Eusphyrna* Gill, 1861 are better treated as genera or subgenera, the latter course, which has customarily been followed by Australian systematists, is adopted here.

FAMILY SPHYRNIDAE

GENUS SPHYRNA Rafinesque, 1810

Cestracion Klein in Walbaum, 1792:580. Type species, *Squalus zygaena* Linné, 1758, by subsequent designation of Gill, 1861. Name inadmissible by International Commission rulings, 1907, 1910.

Sphyrna Rafinesque, 1810:46,60. Type species, *Squalus zygaena* Linné, 1758, by subsequent designation of Jordan & Gilbert, 1883. Gilbert, 1967:10 (synonymy).

Zygaena Cuvier, 1816 ["1817"]:127. Type species, *Squalus zygaena* Linné, 1758, by absolute tautonymy. Preoccupied by *Zygaena* Fabricius, 1775, in Lepidoptera.

Platysqualus Swainson, 1839:318. Type species, *Squalus tiburo* Linné, 1758, by original designation.

Eusphyrna Gill, 1861:403,412. Type species, *Zygaena blochii* Cuvier, 1816 ["1817"], by original designation.

SUBGENUS *Sphyrna* Rafinesque, 1810*Sphyrna* (*Sphyrna*) *zygaena* (Linné, 1758)

The subjoined table of synonymy - restricted, apart from several key extralimital citations, to the Australian literature - includes, for reasons considered below, an unusually large number of cases, now virtually unresolvable, of possible treatment of more than a single species. For overall clarity and typographical economy, the notation "? in part" is here rendered by an asterisk: placed above the author's name, the symbol refers to the entry as a whole; placed above the page number, to the text only, excluding any illustrations; placed above the illustration numbers, to some, not all, items figured.

Squalus zygaena Linné, 1758 "Europe", "America".

Sphyrna zygaena Rafinesque, 1810:46 [specifically, Sicily].? Peters, 1877:132 [Moreton Bay, Queensland]. Ogilvy*, 1889:1769 [east and south coasts of Australia, Tasmania].? Studer, 1889:263 [also in synonymy of *S. lewini* in Whitley, 1934:192; Moreton Bay, Queensland]. Stead*, 1906:232 [list of some Australian sharks]. McCulloch, 1921:221*, pl. 16, fig. 14a [figure after Garman, 1913, pl.1; New South Wales List]. Waite 1921, 14*, fig. 14 [figure after Day, 1878, pl. 186, fig. 4; South Australian list]. Waite, 1923:32, unnumbered fig. [figure after Day, 1878, pl. 186, fig. 4; South Australian list]. Lord*, 1923:61 [Tasmanian list]. Lord & Scott, 1924:6,20*, unnumbered fig. [outline figure, based on Day, 1878, pl. 186, fig. 4; Tasmanian list]. ? McCulloch & Whitley, 1925:129 [Moreton Bay specimen of Peters, 1877; in Queensland list]. Lord*, 1927:12 [Tasmanian list]. McCulloch*, 1929:14 [Australian list; "New South Wales, Queensland, Western Australia, all warm seas"]. Bigelow & Schroeder, 1948:436 [extralimital references and synonymy]. Stead*, 1963:116, fig. 32 [*S. zygaena* discussed, together with *S. tudes*, *S. blochii*; but gloss by Whitley, incorporated in general text, recognizes as Australian only *S. lewini* and *S. ligo*; figure reference in text for *S. zygaena* leads to a figure, under the same vernacular name, but labelled *S. lewini*, reproduction of original figure of Griffith & Smith, 1934, pl. 50]. Gilbert, 1967 a:31, figs 8, 9, 21c, 22c, pl. 6c [references and synonymy; Australian material, USNM 29020 (head), USNM 39992 (1), Sydney (Port Jackson)]. Gilbert, 1967b:76.

Zygaena zygaena Cuvier, 1816 ["1817"]:127.

Zygaena malleus Valenciennes, 1822:223. "French" coasts, Brazil. Castelnau, 1872:216. McCoy, 1881:23, pl. 56, figs 1, 1a-c [species attributed to Shaw, *i.c.*, Shaw, Nat. Misc. t.276; Victoria]. Macleay*, 1882:355 ["Shaw"; "synonyms numerous"; Port Jackson, Port Phillip]. Johnston*, 1883:137 ["Shaw"; cites M. Allport's MS Tasmanian catalogue]. Lucas*, 1890:43 ["Shaw"; cites McCoy, 1881, pl. 56; Victorian list, Port Phillip]. Johnston*, 1891:17 (reprint, 38) ["Shaw"; Tasmanian list].? Waite, 1899:34 [in synonymy of *Thetis* specimen, off Shoalhaven River, New South Wales]; McCoy, 1881, pl. 56 cited; identified as *S. lewini*; probably *S. zygaena*.

? *zygaena lewini* [*sic*] Ramsay, 1881:96 [Port Jackson example; footnote refers to a Queensland specimen (Haswell); not *Zygaena lewini* Griffith & Smith, 1834:640, pl. 50, type locality, "off the south coast of New Holland," *i.e.*, Sydney" (Whitley, 1934:192)].

Sphyrna lewini [not *Zygaena lewini* Griffith & Smith, 1934, as above]. ? Waite, 1899:34 [*Thetis* specimen; see also above under *Z. malleus*]. ? McCulloch, 1911:9 [*Endeavour* specimen, off east coast of Flinders Island, Bass Strait].

Waite, 1921:15 [in synonymy of *S. zygaena*; species attributed to Lord (in Griffith)]. McCulloch & Whitley*, 1925:129 ["Lord"; accept, in Queensland list, Haswell cited by Ramsay, 1881:96 and Ogilby, 1916:81]. McCulloch*, 1929:14 [Australian list]. Whitley*, 1940:120, figs 19, 21, 23, 127, 128A-D [figs 19, 21, 22 aboriginal representations of a hammerhead shark not recognizable specifically; probably not fig. 127, photograph, "appears to be a large *S. tudes*" [= *S. mokarran* (Ruppell, 1835)] (Fraser-Brunner, 1950:213); not figs 128A-D, all of which are *S. lewini*; Australian catalogue]. Whitley, 1948 a:262, text figs 3, 4, pl. 24, figs 1, 2, 2a-b, 3 [19 specimens mentioned; of 4 figured, specimens 2, 3, 5, not 1, appear to be *S. zygaena*]. Whitley*, 1948b:8 [Western Australian list]. Fraser-Brunner, 1950:219, in part, [in synonymy of *S. lewini* places Whitley, 1948a, whose material includes *S. zygaena* (see above)]. Scott*, 1955:60 [South Australian sharks and rays]. Munro, 1956:11*, fig. 73 [not either of figs numbered 73 (reproduction of under surface of head not very clear), which are *S. lewini* after Whitley, 1934, pl. 28, figs A, B]. McCulloch*, 1958, 4:421 [Aust. Encycl. article; reissue after McCulloch's death]. Munro*, 1958:113 [New Guinea]. Scott, 1962:21*, unnumbered fig. [not fig. apparently a redrawing, with some inaccuracies, of Whitley 1934, pl. 28, fig A, which is *S. lewini*]. Goadby, 1963:30, unnumbered fig. [not fig., which shows features not found in any known sphyrid; Australia]. Marshall, 1964:16*, pl. 7, figs 19A, B [not fig., which is *S. lewini*, after Whitley, 1934, pl. 28, figs A, B; Queensland]. Roughley, 1966*:241. Munro, 1967:8*, pl. 1, fig. 7 [not illustration, which is *S. lewini*, after Whitley, 1934, pl. 28, figs A, B; New Guinea]. *Grant, 1972:14, unnumbered fig. [head as shown suggests *S. zygaena* but some features of illustration are not to be found in any species; Queensland].

Cestracion (*Cestracion lewini* Ogilby, 1916:81 [species attributed to Lord; McCoy, 1881, pl. 56, fig. 1 cited; "Coast of South Queensland. Moreton Bay"]).

?? *Sphyrna tudes* Borodin, 1932:69 [South port, Queensland].

Description.- Except where otherwise specified (e.g., "direct"), or where such a convention is clearly inapplicable, dimension in this description are regularly cited as millesimals of total length (between parallels), 610 mm.

Head moderately expanded, greatest width .259, or 1.18 head length (to fifth gill slit), or 1.95 greatest anteroposterior extension of oculonarial expansion, or 4.27 preoral length (to front of upper lip); width at tips of preocular prominences 233. Dorsal profile descending rather rapidly to snout tip, gently, almost evenly, convex, but with slight concavity near its middle; ventral profile about reverse of dorsal below gill slits, in advance of this flatter, slightly sinuous, with small notch at mouth. Dorsal profile of portion of head behind hammerhead expansion and what may be regarded as its forward tumid continuation to tip of snout transversely convex, strongly so over gill slits, decreasingly so anteriorly; dorsal profile of wing-like lateral expansions transversely slightly concave, rising highest at margin above eye. Transverse outline of ventral surface much like that of dorsal, but somewhat less convex mesially in advance of mouth, considerably less convex behind it. Width at level of scallops of anterior border, at tip of preocular prominences, at middle of eye, at first gill slit 4.7, 6.5, 5.2, 1.1 depth at these points; greatest depth of head, found at fifth gill slit, 82, or a little less than one-third greatest head width.

Anterior profile of oculonarial expansion with shallow scallop in each half, equidistant, directly, from naris and tip of snout; median segment moderately and evenly convex, without median concavity, its chord approximately 100, height of its arc 21. Tips of preocular prominences in advance of upper lip by less than an eye diameter. Posterior angle of expansion behind angle of mouth by about an eye diameter; most anterior point on posterior border about level with labial fold; shortest direct distance between anterior border (at nostril) and posterior border 64. Orbit rather large; its horizontal diameter 1.2 its vertical, 2.25 in preorbital length, 1.1 longest (second) gill slit, 1.6 its direct distance from nostril. Narial flaps rather broad, outer edge curving fairly rapidly inward, tip obtusely pointed; free exposed border about one-third eye. Internarial 0.72 greatest width of head, somewhat less than half length to pectoral origin. Inner narial groove well developed, at its anterior extremity curling briefly on to ventral surface near scallop in anterior border of head, its chord 1.06 direct distance from its anterior extremity to tip of snout; distance between anterior tips of grooves 2.62 in greatest head width, rather more than half internarial. Snout 62, a shade less than one-fourth greatest width of head, subequal to shortest direct distance from naris to posterior border of oculonarial expansion. Mandibular symphysis just posterior to a line joining anterior margins of orbits; width of mouth cleft 63, equal to distance from snout tip to midway between front of upper and front of lower lip; small labial furrow at outer angle of lower jaw, shallow groove flanking labial fold internally. Second>first>third>fourth>fifth gill slit, longest 1.4 shortest; fifth behind, fourth above, pectoral insertion; fourth and fifth closest together, distance between them 0.6 length of fifth, remaining intervals increasing anteriorly, being 1.35, 1.67, 1.80 that between fourth and fifth.

Length to first dorsal 266, subequal to interval between hind end of its base and hind end of base of second dorsal, or to distance from pelvic insertion to vent; fin fairly erect, moderately broad; base 3.06 that of second dorsal, 0.41 length of head, 1.83 pectoral base; anterior border almost straight for about 0.7 of its length, thereafter becoming convex, with increasing rapidity distad; tip bluntly rounded, directed backward, a vertical dropped from it intersecting inferior margin of lobe near its mid-point; distal border virtually straight above, briefly concave where it passes into superior border of lobe; lobe 0.3 fin base, superior border very slightly concave, inferior border more concave, most so proximally, slender terminally, pointed; as preserved carried half an eye-diameter above dorsum.

Interdorsal 248, subequal to interval between pectoral and pelvic insertions, 1.1 in upper caudal lobe.

Length to second dorsal 603; origin about 0.62 length of anal base; base 0.69 anal base, subequal to distance between middle of anal base and origin of lower caudal lobe; anterior border at first slightly convex, curving more rapidly posteriorly; distal border slightly concave in anterior half, then becoming virtually straight to constitute superior border of lobe; inferior border of lobe slightly concave in about anterior one-fourth, then virtually straight; lobe slender, pointed, extending 0.56 of distance to precaudal pit.

Length to pectoral 213, subequal to distance between end of its base and middle of ventral base; base 1.83 in first dorsal base, 1.27 in anterior, 0.62 in posterior, interpectoral distance; direct length of fin 0.56 head, 1.25 vertical height of first dorsal; greatest width normal to longitudinal fin axis 0.54 direct length; anterior border convex, slightly so proximally, increasingly so towards tip which is bluntly rounded; distal border moderately falcate, comprising an inner, slightly concave segment, about an eye-diameter long, joined roundedly to an almost straight outer segment about two and a half times as long; internal tip rather rapidly rounded; posterior border

slightly sinuate, with one median concave arc, two terminal convex arcs; distance between margins of two pectorals at lips of inner angle 33, at point of nearest approach 18.

Length to pelvic 457, subequal to distance between middle of pectoral base and origin of lower caudal lobe; base 0.96 anal base; length 0.87 length of anal; anterior border mostly weakly convex, briefly somewhat concave proximally; anterior angle very broadly rounded; distal border virtually straight in first half, gently concave in second; posterior angle acute; posterior border sinuous, concave flanking clasper; clasper short, failing to reach tip of pelvic by about half its own total outer length, or by about one-fourth of its own inner length; subcylindrical; tip rather bluntly rounded.

Length to anal 577, a little more than twice distance between terminations of first and second dorsal bases; base 1.04 pelvic base, 1.44 second dorsal base; height 1.27 height of second dorsal; anterior border briefly concave proximally, later boldly, almost evenly convex; outer angle acute; distal border slightly concave in first half of backwardly directed segment, then strongly concave till it becomes inferior border of lobe, this border barely convex through about three-fourths of its length, thereafter straight; superior border of lobe virtually straight; lobe slender, pointed, its tip reaching just beyond middle of inferior border of lobe of first dorsal; most advanced point on distal border slightly anterior to a perpendicular dropped from the axil.

Length to origin of lower lobe of caudal 692, to origin of upper lobe (at precaudal pit) 711; length of fin (between parallels) 0.31 total length, subequal to interval between end of pectoral base and anal origin. Upper lobe carried at an angle of about 25° to anteroposterior axis of body; length subequal to distance between pectoral origin and end of pelvic base; width (obliquely from precaudal pit to junction with hind border of lower lobe) 3.54 in its length; width at notch equal to vertical diameter of eye; anterior border slightly convex, the fleshy fin fold low throughout its length, obsolescent anteriorly; tip acuminate, somewhat recurved; terminal secondary lobe with its anterior border almost straight, equal in length to width of fin at notch, posterior border slightly emarginate, twice as long; direct length of lobe 5.44 in direct length of caudal; lower border from notch to junction with lower lobe nearly straight, its length equal to distance between end of pelvic base and inferior origin of caudal. Lower lobe of caudal carried at an angle of about 45° ; moderate; length 2.70 in upper lobe; width (slightly obliquely from its origin to junction with lower border of upper lobe) 1.60 in its length; anterior border slightly sinuous, the median one-third or more concave; angle backwardly rounded; posterior border straight.

Length to middle of vent 474; well defined slit 14 long; lips rather quickly elevated along the middle of their length; anterior end reaching to bases of mixopterygia; delimited posteriorly by a narrow membranous band stretched between pelvics, proconcave anterior border free, proconvex posterior border attached. Upper precaudal pit (fig. 1b) proconcave; open, the walls, especially the posterior, rising gradually; width somewhat exceeding length, 3.5 in width of caudal peduncle here. No lower precaudal pit.

Teeth in upper jaw (fig. 1c) 12-0-12; first small, nearly erect, almost symmetrical, the outer edge straight; rest markedly oblique, increasingly so after the first one or two; inner margin smooth or slightly serrate, straight or just barely convex; outer margin smooth, deeply incised; cusps of outermost small but well developed; a few functional teeth of a second row at sides of jaw, with elements of an imperfect third series anteriorly. Teeth in lower jaw 10-1-10; median symphyseal tooth small; in general similar to teeth in upper jaw, but smaller, especially the first three or four, which are slender, more

erect than the rest. On some teeth in which the border is entire it is constituted by a narrow hyaline band within which can be traced a more or less continuous crenulated line.

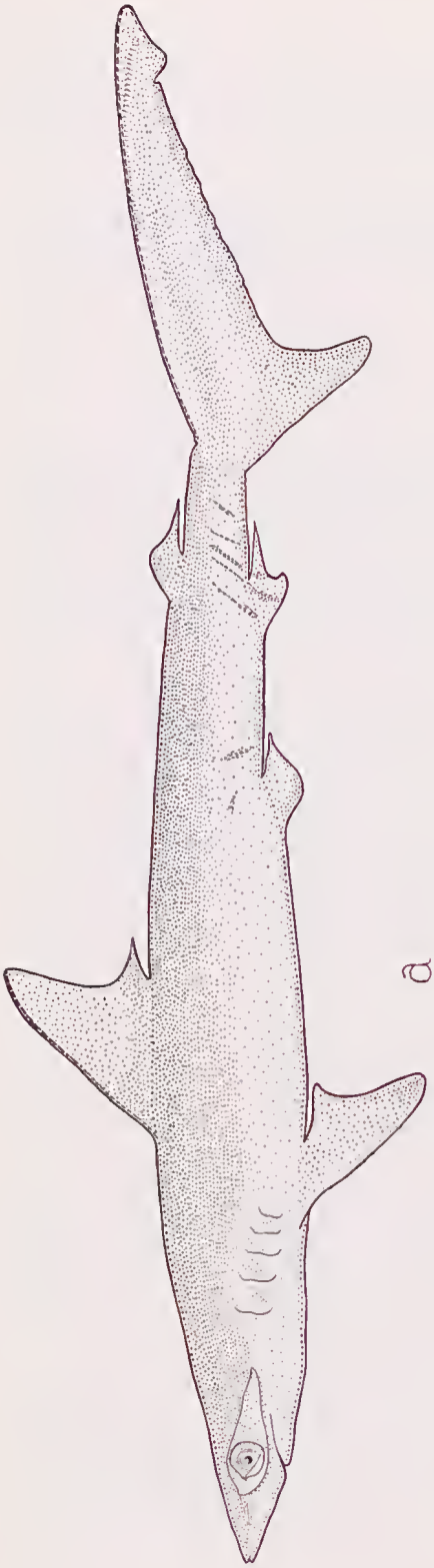
Dermal denticles (fig. 1d) (sample from near base of first dorsal) small, imbricate, blade thin, well arched, total length subequal to width, convex lateral margins diverging rapidly from narrow pedicel; modally three ridges, median strongest and slightly longest, terminating in sharp teeth, margin between teeth strongly excavate.

The disposition of the ampullae of Lorenzini on ventral surface of head is as illustrated (fig. 1e).

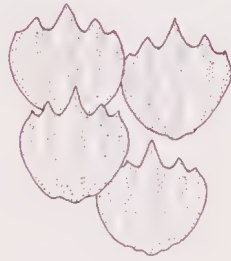
General color dark slaty grey, at times faintly olivaceous, shading without clear line of demarcation into off-white or somewhat yellowish white below; the darker upper area covering about two-thirds of height of body at first dorsal origin, about half at anal origin, rather more than one-third at caudal origin; on sides some small irregular dark markings, differing on the two sides, the most conspicuous four or five streaks running downwards and forwards behind anal. Head whitish below; above concolorous with dorsal surface of body, except for a narrow encroachment of whitish from lower surface on to anterior border, exceeding a millimeter in width mesially, becoming more slender laterally, fading out near middle of paired scallop; between gill slits whitish with some obscure dusky shading; pupil white; iris dark blue; exposed portions of ocular capsule mostly brownish; nictitating membrane whitish, somewhat marbled with dusky. First dorsal with dusky areas basally and near hind border and border of lobe; elsewhere intermediate in color between upper and lower parts of flank, except for a conspicuous black line along anterior border. Second dorsal somewhat lighter than tail nearby; margined with dark brown on anterior border and upper border, with faint continuation along superior (not inferior) border of lobe. Upper surface of pectoral moderately dusky, somewhat lighter anteriorly in preaxial half. Lower surface whitish, with some duskiess near outer angle and very narrowly along posterior border. Pelvic mostly somewhat lighter than dark body color. Anal off-white, crossed by two narrow dark markings, the anterior nearly straight, forwardly oblique, the posterior, near base of lobe, proconvex.

Dimensions.- Table 1 sets out, as thousandths of total length, some dimensions of our specimen: except where otherwise noted (*e.g.*, marked "direct"), or where such a method is clearly inapplicable, dimensions are measured between parallels. The data afford, though at times in another formulation, the information called for by the "set of standard measurements for comparative and biometric studies of Australian sharks" devised by Whitley (1943:114), and includes all dimensions given in the hammerhead revision of Gilbert (1967; table 4); together with some additional items. Of the 21 dimensions in Gilbert's table, 14 are provided for 24 specimens, comprising 8 Atlantic and 10 Pacific examples of length 400-599 mm, 3 Atlantic and 2 Pacific of length 600-799, and 1 Pacific of length > 800, material for the two oceans being exhibited separately; the remaining 7 dimensions are for 23 specimens only, data being unavailable in these entries for the single large Pacific shark. Gilbert lists extreme values and mean for each group: overall extremes and weighted mean are given in the present table.

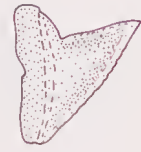
Remarks on the specimen.- The specimen agrees well with the description and figures of *S. (S.) zygaena* in Gilbert (1967), the chief points of



a



d



c1



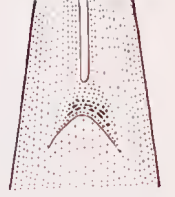
c2



c3



e



b

Fig. 1. - *Sphyrna zygaena* (Linné, 1758): a juvenile male, total length 610 mm, caught by Mr. E. Gatenby in George Bay, Cornwall/Dorset, Tasmania, on 17 April 1970; Queen Victoria Museum Reg. No. 1970.5.14.

- a.- Lateral aspect: x 1/3.
- b.- Upper precaudal pit: x 2.
- c.- Three teeth: x ca 4.

- c₁.- Fourth upper tooth.

- c₂.- An inner (replacement) tooth from anterior part of upper jaw.

- c₃.- Fourth lower tooth.

- d.- Dermal denticles: x ca 50. Sample from right flank 1 cm below middle of base of first dorsal.

- f.- Ventral aspect of head: x 1/3. Semidiagrammatic showing disposition of the ampullae of Lorenzini, and, by a slight tilting, the course of the inner narial groove: elements of chondrocranium, traceable in outline beneath the integument, not depicted.

difference it exhibits being: (i) most advanced point on posterior border of anal occurs barely in advance of ("slightly posterior to") a perpendicular dropped from the axil [see above, comment on specimens figured by Whitley, 1948a]; (ii) values slightly below the minimum reported by Gilbert (1967, table 4) for length of upper border of anal lobe (37: cf. 38), vertical height of anal (21;24), length of caudal (289;290: though the latter measurement may be taken from the lower, here from the upper origin); the adoral arc of ampullae of Lorenzini (fig.1e) is not shown in any figure for any species by Fraser-Brunner (1950, fig. 1a) or Gilbert (1967, fig. 22). With regard to the size and positional relationships of the anal, the following observation by Springer (1964:563), made during the study of carcharinids, may be pertinent. "Usually there would be at least one character in which each specimen of a particular species differed widely from all the remaining. The nature and extent of this variation was greater than I expected from my experience with teleostean fishes." What appear to be two instances of such wide variation are to be found in Table 1, in the entries for length to mouth and horizontal diameter of orbit, for each of which dimensions Gilbert's Table 4 includes one exceptionally low value, cited here with the next lowest value in parenthesis. The dermal denticles examined present a somewhat more convex distal border than those shown by Gilbert (1967, fig. 9e).

Distribution.-*S. S. zygaena* has been cited as a classical case of antitropical distribution, occurring almost universally in warm waters of both hemispheres, but being absent from the tropics. It has been suggested this disjunct north-south range may have developed from a continuous distribution during one or more of the Pleistocene glacial periods. It exhibits seasonal migrations that in the northern hemisphere are well known. McCormick, Allen & Young (1964:349) state, "In the summer, great schools of these Hammerheads migrate northward along the Atlantic seaboard. Many linger round Charleston, South Carolina. Others visit Maryland, New Jersey, and New York waters, sometimes entering New York harbour. Most of the sharks in these warm-weather migrations are small and were probably born shortly before the summer trek began. Dozens of little Hammerheads - each about 30 inches long - are found in nets along the outer shore of Long Island in August. Hammerheads are also in New York waters from July to October. They disappear suddenly when the water temperature falls below 67°F. [19.4°C.]. Where they go after that is not known." A similar state of affairs is noted by Lineaweaver & Backus (1970:89), who state this species occasionally gets as far north as Nova Scotia and the Grand Banks of Newfoundland, "and remains until the autumn water temperature lowers to about 67°F." The same authors state *S. (S.) mokarran* and *S. (S.) lewini* are seldom seen where the water is more than a degree or two below 75°F. [24°C.]. *S. (S.) zygaena* reaches Great Britain, but only rarely.

Little is known of its movements in the southern hemisphere, though similar water temperatures would probably set comparable migratory limits. Two specimens from New Zealand (Bay of Islands) [approximate lat. 35°S.] were examined by Gilbert in his revision, these examples apparently providing (Whitley 1968:7) the first New Zealand record. In Tasmania hammerhead sharks seem seldom to be encountered. It is perhaps of interest to note that in 1971 when Mr Tucker captured his large specimen at St Helens (approximately 41°20'S.) an exceptionally warm water mass moved across Bass Strait to Tasmania - the influence of the East Australian Current, normally confined to eastern Bass Strait and northeastern Tasmania, on this occasion extended even to our west coast. Charts prepared by the C.S.I.R.O. Division of Fisheries and Oceanography (Australian Fisheries, 31 (7):31) show temperatures of 19°C. and over occurred on the east coast from February to April, and unusually high sea temperatures were noted as persisting on the west coast till March.

SPHYRNIDAE IN THE AUSTRALIAN LITERATURE WITH SPECIAL REFERENCE TO

Sphyrna (S.) zygaena AND *S. (S.) lewini*

The entry in the first Australian catalogue of fishes (Macleay, 1882:355) against the sole notice of a hammerhead shark, species 1080, *Zygaena malleus* Shaw [= *Z. malleus* Valenciennes, 1822, a synonym of *Sphyrna (S.) zygaena* (Linné, 1758)] "synonyms numerous" (an unusual comment for Macleay) justifiably calls attention to the general taxonomic disarray of the Sphyrnidae at that time, a disarray that persisted till well into the present century. Generic names proposed for *Sphyrna* reach double figures, as also do the major synonyms of the four valid species described during the eighteenth and nineteenth centuries. While such a state of affairs is by no means without parallel in other groups, a satisfactory sorting out of the family has been specially hindered in the case of the hammerheads by an exceptional measure of uncertainty, continued over a lengthy period, regarding the true characters even of the valid species. (Surprisingly, of the nine species, one with three subspecies, recognised in the important revision of Gilbert [(1967),] three full species and one subspecies were described in 1940 or later). Though a reasonably recognizable figure of *S. lewini* (Griffith & Smith, 1834) [the species is variously attributed by Australian authors to Griffith (usually), Lord, Lord in Griffith, Lord in Griffith (Cuvier): reasons for the attribution to Griffith and Smith jointly have been set out by Gilbert (1967)] was provided by its describers, their description has been spoken of as "almost useless"; and this species has long continued to be confused with the superficially similar *Squalus zygaena* Linné, 1758 (type of *Sphyrna* Rafinesque, 1810): indeed, the distinctness of the two species appears to have been first clearly recognized by Garman (1913), conclusive demonstration of their separateness, with precise specification of its terms, not being achieved till more than a quarter of a century later by Springer (1940). Hence the appropriateness of the use of either of these name in such Australian records as appeared unaccompanied by adequate descriptions of figures (a specification that applies to the great majority, including all Tasmanian ones), up to, at earliest, the publication of Springer's paper (and, indeed, in some instances well beyond that date) are highly suspect. It may be noted, in passing, that even the advance by Springer in 1940 was accompanied, in an extralimital context, by a retrograde step - being at that time unaware that, as has since been shown to be the case, the Pacific and Atlantic populations of *S. lewini* are morphologically indistinguishable, Springer described the latter population as a new species, *S. diplana*. The specific distinctness of *S. lewini* and *S. diplana* was later questioned by Tortonese (1950a), and denied by Fraser-Brunner (1950): the specific identity of the Atlantic and Pacific populations appears evident from the data on 26 individuals of the former and 29 individuals of the latter recorded by Gilbert (1967, Table 5).

The taxonomic history of *Sphyrna zygaena* (Linné, 1758) in Australian literature divides, rather neatly, into two epochs, the formal line of demarcation being drawn at the time of the appearance of McCulloch's checklist (1929), or more precisely, with the publication of a paper by Whitley (1934). The earlier period is characterized by the variable use, in respect of local records, of the names *S. zygaena* (or the synonymic *S. malleus*) and *S. lewini*, the choice, in at least some instances, seemingly being dependent on nothing more than the writer's familiarity with the literature, or on his views on the likely, or unlikely, distinctness of northern and southern hemisphere faunas. The later period witnesses the almost universal acceptance of the occurrence in Australian waters of only one of these two species, *S. zygaena* all but disappearing from the local literature. In the course

of a similar revisionary process, *S. blochii* (Cuvier, 1816) [date of publication, which continues to be given - e.g., by Fraser-Brunner (1950), Gilbert (1967) - as 1817, is Dec. 1816] and *S. tudes* (Valenciennes, 1822), reported from Australia up to 1929, are absent from all important recent lists, which admit only *S. lewini* or that species and *S. ligo* Fraser-Brunner, 1950.

Published Tasmanian lists, each with a single hammerhead entry, all fall within the earlier period, Johnston (1883, with citation of MS list of Allport; 1891) giving *Zygaena malleus* Shaw, Lord (1923, 1927) giving *Sphyrna zygaena* Linné. It is not possible now to determine whether these entries relate solely to *S. zygaena*, solely to *S. lewini*, or to both these species (or, improbably, to some other species or combination of species).

A concise indication of the manner in which *S. zygaena* and *S. lewini* appear side by side in Australian works prior to 1934, with the former predominating early, is provided by an enumeration of some notable references. *Z. malleus* Shaw [= *Z. malleus* Valenciennes 1822 = *S. zygaena* Linné, 1758]: Castelnau (1872:216), McCoy (1881), Macleay (1882), Johnston (1883), Lucas (1890), Johnston (1891), Waite (1899, in synonymy). *Sphyrna zygaena*: Peters (1877: Australian record), Ogilby (1888), Studer (1889, Australian record), Stead (1906), McCulloch (1919), Waite (1921), Waite (1923), Lord (1923), Lord & Scott (1924), McCulloch & Whitley (1925), Lord (1927), McCulloch (1929). *Zygaena lewini* Ramsay (1881; "leuwini"). *Sphyrna lewini*: Waite (1899), McCulloch (1911), Ogilby (1916, *Cestracion*), Waite (1921, in synonymy), McCulloch & Whitley (1925), McCulloch (1929).

In the Australian check-list McCulloch included all species till then reported from our waters, namely, *Sphyrna (Eusphyrna) blochii* (Cuvier, 1816), *S. (S.) lewini*, *S. (S.) zygaena* with *S. (S.) malleus* Valenciennes, 1822 as synonym, *S. (Platysqualus) tudes* (Valenciennes, 1822). Five years later, Whitley (1934:192, pl. 28) provided a description and figure of the female 23 inches long from Moreton Bay that had previously been recorded by Ogilby (1908:4) as *Sphyrna tudes*, and later (1916:82, 94) catalogued by him as *Cestracion (Platysqualus) tudes*; correctly determining the specimen as *S. lewini* (his figure being much in use since). At the conclusion of the same paper, in listing the sharks of Australia and New Zealand he accordingly dropped *S. tudes*, retaining, however, *S. blochii*, *S. lewini* and *S. zygaena*.

Since 1934 *S. zygaena* has virtually disappeared from the Australian literature (and with it have gone *S. blochii* and *S. tudes*). Thus in the three important all-Australian catalogues the position is as follows: in *The Fishes of Australia: Part 1, The Sharks...* Whitley (1940) accepts *S. lewini* only, remarking (p. 121) "I think there is only one species in Australasia, but it has been recorded under various specific names; *zygaena*, *tudes*, *malleus*, *blochii*, etc."; in the *Handbook of Australian Fishes* Munro (1956) recognizes only *S. lewini* (giving Whitley's 1934 figures - see above: in the reproduction of the head the median scallop is by no means clearly defined) and *S. ligo* Fraser-Brunner, 1950 (giving original figures); in the most recent survey the name-list of Whitley (1964), there likewise are found *S. lewini* and *S. ligo* only. While Stead's *Sharks and Rays of Australian Seas* (1963), published several years after the author's death, discusses three species, *S. zygaena*, *S. tudes* and *S. blochii* (not, curiously, *S. lewini*) a revisionary passage, contributed by Whitley and incorporated in the general text, cites Fraser-Brunner's 1950 revision, and reduces the species to two, *S. lewini* and *S. ligo*, noting "the kinds called in Australia *Sphyrna lewini*, *S. tudes* and *S. blochii* are considered to be *S. lewini*." *S. lewini* only is mentioned in *Fish and Fisheries of Australia* (Roughley, 1966, first published 1951) and in *Sharks and Other Predatory Fish of Australia* (Goady, 1968, first published 1963) [poor figure, p. 31, showing features not to be found in any known sphyrid].

McCulloch's contribution on hammerheads to the *Australian Encyclopaedia* (1958, 4:421; re-issue, after McCulloch's death) states "Several species are known", adding "A common species in Australia is *Sphyrna lewini*". A specific Australian locality appears in Fraser-Brunner's synopsis only for his *S. ligo* (New South Wales), though two references to Australian literature (Whitley, 1934, 1948; see observations on latter, below) are listed for *S. lewini*: his distribution of *S. zygaena* is "Coasts of Atlantic Ocean; Mediterranean; eastern Pacific Ocean; Japan."

In works dealing with a single Australian State issued after 1934 *S. lewini*, and that species only, is reported for Western Australia (Whitley 1948, b:8); for South Australia in two publications (Scott, 1955, 1962) [in 1962 work (p. 21) original plate-number in Griffith & Smith is given as 1, instead of 50; probably through confusion between roman and arabic numerals; the same error has crept into other texts, perhaps the most recent the New Zealand check-list (Whitley, 1968:7)]; for Queensland by Marshall (1966; "one species in Queensland":16), and by Grant (1972; second edition) [poor figure, p. 14, with features not found in any hammerhead; no median scallop on head]. Earlier, McCulloch (1919) gave only *S. lewini* for New South Wales. In both his New Guinea check-list (1958) and his comprehensive work on the fishes of New Guinea (1967) Munro records *S. lewini* only.

Whitley has given some notes on a specimen of *S. lewini* from Bateman's Bay, New South Wales (1937) [unusual, but not unparalleled, in possessing a lower precaudal pit], and has incidentally noted an example from New Guinea (1949).

While the name *S. zygaena* thus almost completely dropped out of Australian systematics from 1935 onwards, specimens of this species appear to have been collected, and even to have been reported under another name, between that date and the present time. Thus among 18 hammerhead sharks from Western Australia and 1 from Queensland, all identified as *S. lewini*, field notes on which have been provided by Whitley (1948a) at least several individuals appear to be *S. zygaena*. Outlines of the heads of 4 individuals (specimens 1, 2, 3, 5) are given (text fig. 3, pl. 24, figs 1, 2, 3), together with a sketch (text fig. 4) showing the relationships and proportions of second dorsal, anal and caudal fins in specimens 2 and 3, and an illustration (pl. 24, fig. 2b) of the skull of specimen 5 in situ. Only one head outline (pl. 24, fig. 3) presents a median scallop, that of specimen 1, a female from Queensland (Connor's Creek, Fitzroy River estuary): this appears to be *S. lewini* (??*S. mokarran*; situation regarding narial grooves not clear). The anterior contour of the head lacks a median scallop in specimen 2 (pl. 24, fig. 1), a female from Western Australia (off Bald Head, Albany), specimen 3 (text fig. 3), a male from Western Australia (West of Station Island, Recherche Archipelago), and specimen 5 (pl. 24, figs 2, 2a-b), a female from Western Australia (off Second Beach Point, Esperance). In the light of present knowledge and on the basis of the heads, these 3 specimens may be taken to be *S. zygaena*; an identification that appears wholly satisfactory in the case of specimen 3, in the illustration of which (text fig. 3) the clearly shown inner narial grooves are depicted as extending >50% <55% of the direct distance from naris to snout tip. However, it should be noted that, while the extent of prolongation in the second dorsal and anal lobes of specimens 2 and 3 (text fig. 4) is compatible with *S. zygaena*, in both specimens the most anterior point on the posterior border of the anal lies anterior [Gilbert (1967:33) "slightly posterior"] to a perpendicular dropped from the axil of the fin [slightly anterior also in our specimen]. It must further be observed that by citing this paper (including references to illustrations) under *S. lewini* Fraser-Brunner (1950:219) presumably accepted all the material it deals with as belonging to that species.

Both *S. zygaena* and *S. lewini* are recorded from Australia in Gilbert's 1967 revision, the former on the basis of specimens examined [USNM 29020 (head), USNM 39992 (i), Sydney (Port Jackson)]; with the latter in the species distribution map (map 3) with a notation for "confirmed literature reference" [presumably that of Gilbert & Smith, 1834].

SYNOPSIS OF SPHYRNIDAE REPORTED FROM AUSTRALIA

Hammerhead sharks have been reported from Australian waters under seven specific names (in several generic and subgeneric combinations) these are here briefly reviewed.

(i) *S. malleus* (Valenciennes, 1822) - regularly attributed locally to Shaw. Synonym of (ii). Chief entries listed above. Australian description: McCoy (1881:23)[measurements only]; ? Waite (1899:34) [as *S. lewini*]. Australian figure: McCoy (1881, pl. 56, fig. 1) [lithograph by Schonfeld not very good].

(ii) *S. zygaena* (Linné, 1758). Chief entries listed above. Australian description: McCoy (1881):?Waite (1899), as above for (i). Australian figure: McCoy, 1881, as above for (i).

(iii) *S. lewini* (Griffith & Smith, 1834). Chief entries listed above. Australian descriptions: ?Waite (1899:34); Whitley (1934:192)[Ogilby's 1908 specimen from Moreton Bay, Queensland, reported by him as *S. tudes*]; Whitley (1937:4)[Bateman's Bay, New South Wales]; ?Whitley (1948:262) [? some of 19 individuals, in particular specimen 1]. Australian figures: Whitley (1934, pl. 28); ? Whitley (1948, pl. 24, fig. 3); Whitley in Fraser-Brunner (1950, fig. 3)[Menapi, Goodenough Bay, Papua; "G. P. Whitley, del.", no reference]; illustrations in Goadby (1963:31) and Grant (1972:14) are scientifically worthless.

(iv) *S. blochii* (Cuvier, 1816). In listing this species as a new record for Australia Ogilby (1908:4) stated only "The [Queensland] Museum possesses a couple of fetal examples of this unmistakable shark taken from a female killed in Rockingham Bay." Though occurring in the Queensland check-lists of Ogilby (1916) and McCulloch & Whitley (1925), and surviving to appear in the Australian check-list (McCulloch, 1929), this record has since been overlooked, ignored or rejected. *S. blochii* differs trenchantly from all other species in having the nostril situated far from the eye, about halfway to tip of snout; the question naturally presents itself as to whether it was the presence in his specimen of this feature in his specimen that prompted Ogilby's "unmistakable". Gilbert (1967, map 1) includes in his distribution map a symbol denoting "confirmed literature reference" on the Queensland coast and notes in the text "The species has also been recorded from Queensland, Australia (Ogilby, 1908, p.4); this area apparently represents both the eastern and southern limits of its range." Mr R. J. McKay, Curator of Fishes, Queensland Museum, Brisbane, has been good enough to make a search for Ogilby's material and he informs me it is not listed in their 1969 index of tank specimens, and does not now appear to be traceable. Mr McKay adds he has examined, in the light of Gilbert's 1967 revision, four hammerhead sharks in the collection labelled *Sphyrna zygaena* and finds them all to be *S. lewini*.

(v) *S. tudes* (Valenciennes, 1822). Fraser-Brunner called attention to some confusion in the application of the name *S. tudes*, and Tortonese (1950b) showed the three types comprise two species - these have been identified by Gilbert as *S. tudes* (two types extant) and probably *S. mokarran* (Rüppell, 1835) (type lost: identification partly by locality), the former being restricted to the western Atlantic and the western Mediterranean. With *S. mokarran* Gilbert synonymizes *S. ligo* Fraser-Brunner from New South Wales. As noted above, the hammerhead recorded by Ogilby as *S. tudes* has been shown by Whitley to be *S. lewini*. Fraser-Brunner has remarked of a photograph given by Whitley (1940, fig. 127) of a shark from Broome that it "appears to be a large *S. tudes*." This would presumably be *S. mokarran*; and *S. tudes* has no real place in the Australian list.

(vi) *S. ligo* Fraser-Brunner, 1950. Treated by Gilbert as a synonym of (v). Australian description: Fraser-Brunner (1950:214). Australian figures: Fraser-Brunner (1950, fig. 1, fig. 2, part). The present writer is not in a position to express an informed opinion as to whether or no *S. ligo* and *S. mokarran* are conspecific. However, attention may be called to some discrepancies between Fraser-Brunner's account of the former and Gilbert's account of the latter. (i) "*S. mokarran* is unique among members of the genus *Sphyrna* in having ... strongly serrated teeth at all sizes;" teeth of *S. ligo* as figured appear to be smooth (no reference, in description, to margins); (ii) antero-lateral pore series figured as an arc of subequal width throughout, in *S. ligo* as a broad subelliptical patch; (iii) figure for *S. mokarran* shows on each side an imperfect continuation of the arc running backwards and outwards, the tips of the two continuations being connected by a line of pores, slightly forwardly convex, situated about five times as far from snout tip as from mouth; figure for *S. ligo* has no such continuations, the posterior tips of the patches being connected directly by a virtually straight line of pores, situated two-three times as far from snout tip as from mouth; (iv) first dorsal base "almost twice" (*S. mokarran*), "one and a third" (*S. ligo*) pectoral base; (v) anal base "slightly (up to one-sixth) longer" than second dorsal base (*S. mokarran*); second dorsal base "a little longer" than anal base (*S. ligo*). The marked difference in the form of the first dorsal in the illustration (from Bigelow & Schroeder, 1948) of a juvenile male of *S. mokarran*, 673 mm long reproduced in Gilbert and in Fraser-Brunner of his type, 325 mm long from tip of snout to precaudal pit, appears to be covered by Gilbert's note on the fin "excessively curved in embryonic and post-embryonic individuals." [In Fraser-Brunner's "Base of dorsal fin contained three and a quarter times in length of head.", "three" should read "two".]

(vii) *S. mokarran* (Rüppell, 1835). See remarks above on status of this species under *S. tudes*. Reported from Australia by Gilbert (1967:26) on the basis of material examined: "Pacific Ocean: Australia: USNM 40014 (1), USNM 40026, (1), MCZ 969 (1) Richmond River, New South Wales"; with an additional item concerning *S. ligo* Fraser-Brunner, "BMNH 1890.9.23.231 (X-ray of head of holotype of *Sphyrna ligo*), Clarence River, New South Wales." *S. mokarran* does not appear hitherto to have entered the Australian literature; for extralimital references see Gilbert, above, Springer (1944).

The list of Australian Sphyrnidae, given in recent local lists as *S. (S.) lewini* and *S. (S.) ligo*, thus becomes, in the light of our present knowledge: *S. (S.) zygaena* (Linné, 1758), *S. (S.) lewini* (Griffith & Smith, 1834), *S. s. mokarran* (Rüppell, 1835) [with *S. (S.) ligo* Fraser-Brunner, 1950 as a probable synonym] as satisfactorily recorded species, with the inclusion of *S. (E.) blochii* (Cuvier, 1816) in some doubt.

KEY TO SPECIES REPORTED FROM AUSTRALIA

- Outer narial groove present; nostril farther from eye than from tip of snout. Head width ≥ 1.5 ($\approx 1.5-2.3$, modally > 2.0) head length. Vertebrae < 150 (known range 117-124).....*S. (E.) blochii*
- Outer narial groove absent; nostril closer to eye than to tip of snout. Head width < 1.5 ($= 1.0-1.3$, modally ≤ 1.2) head length. Vertebrae > 150 (known range 179-204).....2
- Inner narial groove absent (represented by a thin line). Perpendicular dropped from apex of first dorsal passing behind tip of fin lobe. Length of anterior margin and vertical height of second dorsal both $<$ those of anal. Teeth strongly serrate at all sizes.....*S. (S.) mokarran*
- Inner narial groove present. Perpendicular dropped from apex of first dorsal intersecting fin lobe. Length of anterior margin and vertical height of second dorsal both $<$ those of anal. Teeth smooth in young, sometimes weakly serrate in adults3
- Median segment of anterior border of head without a scallop. Inner narial groove extending $> \frac{1}{2}$ distance from inner margin of naris to tip of snout. Distance from naris to orbit $< (\approx \frac{1}{2})$ diameter of eye. Lobe of second dorsal extending $\leq \frac{2}{3}$ distance from fin base to precaudal pit. Lateral borders of median anterior patch of pores on ventral surface of head concave, series narrowing posteriorly to a point of one or two pores. Rostral fenestra present. Lower precaudal pit absent.....*S. (S.) zygaena*
- Median segment of anterior border of head with a scallop. Inner narial groove extending $< \frac{1}{2}$ (0.4-0.45) distance from inner margin of naris to tip of snout. Distance from naris to orbit \approx diameter of eye. Lobe of second dorsal extending $> \frac{2}{3}$ ($\approx \frac{3}{4} - \frac{4}{5}$) distance from fin base to precaudal pit. Lateral borders of median anterior patch of pores on ventral surface of head straight or barely convex, ending behind in a transverse line, its length about half greatest width of patch. Rostral fenestra usually absent. Lower precaudal pit usually absent*S. (S.) lewini*

If *S. (S.) ligo* is to distinguished from *S. (S.) mokarran*, an examination should be made of the margin of the teeth, the disposition of the ampullae of Lorenzini, and the relative sizes of the bases of the two dorsals, the pectoral and the anal fins; and reference made to the text above.

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TABLE 1

Sphyrna (S.) zygaena (Linné, 1758). Dimensions, as thousandths of total length, of a male 610 mm long from George Bay Tasmania: with comparative data for 24 (asterisked entries 23) Atlantic and Pacific examples from Gilbert (1967, table 4).

DIMENSION	TASMANIA	ATLANTIC AND PACIFIC: RANGE (WEIGHTED MEAN)
Length to first gill slit	162	162-192 (177.1)
Length to fifth gill slit	220	210-245 (228.6)
Length to mouth: upper lip, angle	61,109	
Length to mouth: mandibular symphysis	66	45[62]-77 (66.6)
Width of mouth: cleft, tips of labial folds	63, 67	
Width, depth of head: at midpoint of scallops	98, 21	
: at tips of preocular prominences	233, 36	
: At first gill slit	95, 74	
: at fifth gill slit	74, 85	
: maximum	259, 85	260-290 (267.3),
Length to eye: parallels, direct from tip of snout (profile)	62, 138	
Horizontal diameter of eye, of orbit	24, 26	-, 12[23]-30 (25.8)
Vertical diameter of eye, of orbit	21, 22	
Interorbital	248	
Length to nostril: parallels, direct from tip of snout (profile)	49, 106	
Internarial	190	186-209 (190.7)
Length of inner narial groove (chord)	56	
Anterior end of narial groove direct to tip of snout (profile)	54	
Distance between anterior ends of narial grooves	101	
Nostril to eye, to orbit	16, 15	
Length of second (largest) gill slit, of fifth	22, 17	
First dorsal: length to origin	266	263-291 (272.3)
: base	90	86-105 (96.0)
: length of anterior border, of distal	139, 82	
: length of lower border of lobe	26	
: vertical height	103	
Interdorsal	248	221-253 (237.9)*
Second dorsal: length to origin	603	589-635 (606.4)
: base	30	25- 38 (32.3)
: length of anterior border, of distal	31, 41	
: length of lower border of lobe	44	43- 52 (46.0)*
: vertical height	16	16- 23 (19.5)*
Anal: length to origin	577	
: base	43	42- 57 (46.5)*
: length of anterior border, of distal	44, 38	
: length of upper border of lobe	37	38- 45 (42.0)*
: vertical height	21	24- 29 (28.6)*

continued

Pectoral: length to origin	213	195-226	(212.1)
: base	49	47- 60	(49.2)*
: length of anterior border, of distal	113, 75		
: length of posterior border	38		
: total length	125		
: maximum width normal to longitudinal axis	110		
Interpectoral: at anterior end of base, at posterior end	62, 30		
Pelvic: length to origin	457	438-468	(449.2)
: base	40		
: length of anterior border, of distal	41, 44		
: length of posterior border, total, free	35, 20		
: total length	69		
: maximum width normal to longitudinal axis	39		
Interpelvic: at anterior end of base, at posterior end	39, 15		
Clasper: length of inner border	41		
: length of outer border, total, free	19, 13		
: maximum width, maximum depth	6, 5		
Upper lobe of caudal: length to origin (at precaudal pit)	711		
: base (precaudal pit to junction with lower lobe)	81		
: length of anterior border, of posterior below notch	289, 193	290-312	(300.3)
: terminal lobe; anterior border, posterior	20, 40		
: width at notch	21		
Lower lobe of caudal: length to origin	692		
: base (slightly oblique)	67		
: length of anterior border, of posterior	107, 55		
Length to end of vertebral column	982		
Length to vent (middle)	474		
Depth, width: at first dorsal origin	95, 72		
: at pelvic origin	79, 56		
: at anal origin	57, 41		
: at caudal peduncle (minimum)	38, 30		
: maximum (body)	97, 74		